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TEL 650.330.2310
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ORIGINAL TO FOLLOW? ☐ YES ☒ NO

APPEAL BRIEF

TITLE: INTEGRATION OF BARRIER LAYER AND SEED LAYER
U.S. SERIAL NO.: 09/965,370
FILING DATE: September 26, 2001
INVENTOR: CHUNG, et al.
EXAMINER: Eric B. Fuller
GROUP ART UNIT: 1762
CONFIRMATION NO.: 6507

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for FY 2006**☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$ 600.00)

Complete If Known

Application Number	09/085,370
Filing Date	September 26, 2001
First Named Inventor	Hua CHUNG
Examiner Name	Eric B. Puller
Art Unit	1762
Attorney Docket No.	APPW008305/GP/COPPER/PJ8

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

Application Type	FILING FEES		SEARCH FEES		EXAMINATION FEES		Fees Paid (\$)
	Fee (\$)	Small Entity Fee (\$)	Fee (\$)	Small Entity Fee (\$)	Fee (\$)	Small Entity Fee (\$)	
Utility	300	150	500	250	200	100	—
Design	200	100	100	50	130	65	—
Plant	200	100	300	150	160	80	—
Reissue	300	150	500	250	600	300	—
Provisional	200	100	0	0	0	0	—

2. EXCESS CLAIM FEES

Fee Description

Each claim over 20 (including Reissues)

Each independent claim over 3 (including Reissues)

Multiple dependent claims

Total Claims	Extra Claims	Fee (\$)	Fee Paid (\$)	Small Entity Fee (\$)	Small Entity Fee Paid (\$)
—	—	—	—	—	—

-20 or HP=

x

=

HP = highest number of total claims paid for. If greater than 20.

Indep. Claims	Extra Claims	Fee (\$)	Fee Paid (\$)
—	—	—	—

-3 or HP=

x

=

HP = highest number of independent claims paid for. If greater than 3.

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequences or computer listings under 37 CFR 1.52(e)), the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(a).

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof	Fee (\$)	Fee Paid (\$)
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4. OTHER FEE(S)

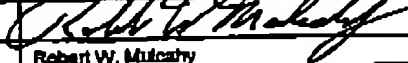
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Fees Paid (\$)

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Signature		Registration No. (Attorney/Agent)	25,438	Telephone	(713) 823-8582
Name (Print/Type)	Robert W. Mulcahy	Date	July 31, 2006		

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Patent

Atty. Dkt. No. APPM/006303/CPI/COPPER/PJS

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

In re Application of:
CHUNG, et al.

Serial No.: 09/965,370

Confirmation No.: 6507

Filed: September 26, 2001

For: **INTEGRATION OF
BARRIER LAYER AND
SEED LAYER**

Group Art Unit: 1762

Examiner: Eric B. Fuller

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Dear Sir:

APPEAL BRIEF

Applicants submit this Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1762 dated April 28, 2006, finally rejecting claims 1-7, 9-10, 39, 42, and 44-69. The final rejection of claims 1-7, 9-10, 39, 42, and 44-69 is appealed. This Appeal Brief is believed to be timely since mailed by the due date of July 31, 2006, as set by mailing a Notice of Appeal on May 30, 2006. Authorization to charge the fee of \$500.00 for filing this brief is provided on a separate fee transmittal. Please charge any additional fees that may be required to make this Appeal Brief timely and acceptable to Deposit Account No. 20-0782/APPM/006303/KMT.

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7/31/06

Date 7/31/06 By Felix Chen, 51,553

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Real Party in Interest

The present application has been assigned to Applied Materials, Inc., 3050 Bowers Avenue, Santa Clara, California 95054.

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Related Appeals and Interferences

Applicant asserts that no other appeals or interferences are known to the Applicant, the Applicant's legal representative, or assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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Status of Claims

Claims 1-7, 9-10, 39, 42, and 44-69 are pending in the application. Claims 1-69 were originally presented in the application. Claims 8, 11-38, 40-41, and 43 have been cancelled without prejudice.

Claims 1-7, 9-10, 39, 42, and 44-69 stand finally rejected as discussed below. The final rejection of claims 1-7, 9-10, 39, 42, and 44-69 is appealed.

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Status of Amendments

All claim amendments have been entered by the Examiner. Amendments to the claims presented after the final rejection have been entered by the Examiner and included in the Claims Appendix.

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Summary of Claimed Subject Matter

Claimed embodiments of the invention provide a method of filling a feature. The method includes depositing a barrier layer, depositing a seed layer over the barrier layer, and depositing a conductive layer over the seed layer. In one aspect, the seed layer comprises a copper alloy seed layer deposited over the barrier layer. For example, the copper alloy seed layer may comprise copper and a metal, such as aluminum, magnesium, titanium, zirconium, tin, and combinations thereof. In another aspect, the seed layer comprises a copper alloy seed layer deposited over the barrier layer and a second seed layer deposited over the copper alloy seed layer. The copper alloy seed layer may comprise copper and a metal, such as aluminum, magnesium, titanium, zirconium, tin, and combinations thereof. The second seed layer may comprise a metal, such as undoped copper. In still another aspect, the seed layer comprises a first seed layer and a second seed layer. The first seed layer may comprise a metal, such as aluminum, magnesium, titanium, zirconium, tin, and combinations thereof. The second seed layer may comprise a metal, such as undoped copper. (See, Abstract)

In one embodiment, a copper alloy seed layer 502 is deposited over a barrier layer 204 and a copper conductive material layer 506 is deposited over the copper alloy seed layer 502 to fill the feature. (See, Figures 5A and paragraph 53.) In another embodiment, a copper alloy seed layer 512 is deposited over a barrier layer 204, a second seed layer 514 is deposited over the copper alloy seed layer 512, and a copper conductive material layer 516 is deposited over the second seed layer 514 to fill the feature. (See, Figure 5B and paragraph 54.) In another embodiment, a first seed layer 523 is deposited over a barrier layer 204, a second seed layer 524 is deposited over the first seed layer 523, and a copper conductive material layer 526 is deposited over the second seed layer 524 to fill the feature. (See, Figures 5C and paragraph 56.)

In the embodiments of independent claim 1, a method for filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition (pages 6-7, paragraphs 27-29), the barrier layer having a thickness less than about 50 Å (page 10,

paragraphs 31-36, and page 11, paragraph 42), depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (page 13, paragraph 53 and page 17, paragraph 62), and then depositing a copper conductive material layer over the seed layer (page 13, paragraph 53, and page 16, paragraph 61).

In the embodiments of independent claim 39, a method of preparing a substrate structure for copper metallization is provided, comprising depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less (pages 6-7, paragraphs 27-29, and page 11, paragraph 42), and then depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (page 13, paragraph 53 and page 17, paragraph 62).

In the embodiments of independent claim 42, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å (pages 6-7, paragraphs 27-29), depositing a copper alloy seed layer over the barrier layer (page 13, paragraph 53 and page 17, paragraph 62), the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent (page 13, paragraph 53), the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (page 13, paragraph 53 and page 17, paragraph 62), and then depositing a copper conductive material layer over the copper alloy seed layer (page 13, paragraph 53, and page 16, paragraph 61).

In the embodiments of independent claim 47, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å (pages 6-7, paragraphs 27-29), depositing a copper alloy seed layer over the barrier layer (page 14, paragraph 55), the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent (page 14 paragraph 55), the metal selected from the group consisting of aluminum, magnesium, zirconium, and

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combinations thereof (page 14, paragraph 55); depositing a second seed layer over the copper alloy seed layer (page 14, paragraph 55), and then depositing a copper conductive material layer over the second seed layer (page 14, paragraph 55, and page 16, paragraph 61).

In the embodiments of independent claim 53, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å (pages 6-7, paragraphs 27-29), depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å (page 15, paragraphs 57-58), the first seed layer comprising aluminum (page 15, paragraph 57), depositing a second seed layer over the first seed layer (page 15, paragraph 57), and depositing a conductive material layer over the second seed layer (page 15, paragraph 57, and page 16, paragraph 61).

In the embodiments of independent claim 59, a method of preparing a substrate structure for electroplating of copper is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å (pages 6-7, paragraphs 27-29), and depositing a seed layer over the barrier layer, the seed layer comprising copper and aluminum (page 13, paragraph 53 and page 17, paragraph 62).

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Grounds of Rejection to be Reviewed on Appeal

1. Claims 1-7, 9-10, 39, 42, and 44-69 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin et al.* (U.S. Patent No. 6,174,799).

2. Claims 42 and 44-69 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* (U.S. Patent No. 6,309,964).

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ARGUMENTS

A. Rejection of Claims 1-7 and 9-10 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799

Claims 1-7 and 9-10 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. The Examiner states that *Lopatin et al.* '954 teaches a barrier layer of 20-300 angstroms formed by atomic layer deposition and *Lopatin et al.* '799 teaches nitrogen grading in copper alloyed seed layers to increase adhesion to the barrier layer and decrease electro-migration. The Examiner states that it would have been obvious to use the constituents of the seed layer of *Lopatin et al.* '799 in the process of *Lopatin et al.* '954 to reap the benefits of the bulk copper layer having better adhesion to the barrier layer and decreased electro-migration.

Applicants have respectfully traversed the rejection based on the failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claimed subject matter. *Lopatin et al.* '954 teaches a barrier layer of 20-300 angstroms formed by atomic layer deposition (ALD), a pre-seed layer comprising copper formed by atomic layer epitaxy, and a seed layer comprising copper formed by chemical vapor deposition (CVD). *Lopatin et al.* '799 teaches a method depositing a seed layer over a barrier layer, the seed layer comprises a conductive metal material alloyed with a nitrided metal material, having a graded nitrogen content.

However, *Lopatin et al.* '954 in view of *Lopatin et al.* '799 does not teach, suggest, or motivate depositing of a seed layer, which comprises copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, to be deposited over a thin barrier layer which is deposited by atomic layer deposition to a thickness of less than about 50 Å. The Examiner has failed to show a clear and particular motivation by the skilled artisan to select from the disclosures of *Lopatin et al.* '954 and *Lopatin et al.* '799. The only suggestion is provided in the Applicant's disclosure and thus hindsight.

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Applicant submits that "[t]he showing of a motivation to combine must be clear and particular, and it must be supported by actual evidence. In *re Dembiczak*, 50 U.S.P.Q. 2d 1614, 1617 (Fed. Cir. 1999). The Federal Circuit has also ruled that "[o]ne cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." (In *re Fritch* at 1784). The only suggestion of the claimed subject matter is provided in the Applicant's disclosure, and thus the claims were rejected in hindsight.

Applicant asserts that a copper alloyed seed layer to be deposited over a thin ALD deposited barrier layer is not taught or suggested in the combination of *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 50 Å, depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, and then depositing a copper conductive material layer over the seed layer, as recited in claim 1 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

B. Rejection of Claim 39 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799

Claim 39 stands rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejection based on the failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of claim 39.

Lopatin et al. '954 in view of *Lopatin et al.* '799 does not teach, suggest, or motivate depositing of a seed layer, which comprises copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, to be deposited over a thin barrier layer which is deposited by atomic layer deposition to a sidewall coverage of about 50 Å or less. The Examiner has failed to show a clear and particular motivation by the skilled artisan to select from the disclosures of *Lopatin et al.* '954 and *Lopatin et al.* '799. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799,

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alone or in combination, does not teach, show, or suggest a barrier layer deposited to a sidewall coverage of about 50 Å or less.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less, and then depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, as recited in claim 39. Withdrawal of the rejection is respectfully requested.

C. Rejection of Claims 42, 44-46 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799

Claims 42, 44-46 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 42 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, and then depositing a copper conductive material layer over the copper alloy seed layer, as recited in claim 42 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

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D. Rejection of Claims 47-52 over *Lopatin et al.*'954 in view of *Lopatin et al.* '799

Claims 47-52 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 47 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent. Further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a second copper seed layer to be deposited over a copper alloy seed layer comprising copper and a metal.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, depositing a second seed layer over the copper alloy seed layer, and then depositing a copper conductive material layer over the second seed layer, as recited in claim 47 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

E. Rejection of Claims 53-58 over *Lopatin et al.*'954 in view of *Lopatin et al.* '799

Claims 53-58 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 53 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a first seed layer comprising aluminum. Furthermore, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a second seed layer deposited over a first seed layer comprising aluminum. Still further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a first aluminum seed layer deposited to a sidewall coverage between a sub-monolayer and about 50 Å to be deposited over a thin barrier layer having a thickness of less than about 20 Å.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å, the first seed layer comprising aluminum, depositing a second seed layer over the first seed layer, and depositing a conductive material layer over the second seed layer, as recited in claim 53 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

F. Rejection of Claims 59-69 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799

Claims 59-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 59 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a seed layer comprising copper and aluminum to be deposited over a barrier layer deposited by ALD to a thickness of less than about 20 Å.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, and depositing a

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seed layer over the barrier layer, the seed layer comprising copper and aluminum, as recited in claim 59 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

G. Rejection of Claims 42, 44-46 over *Lopatin et al.*'954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*

Claims 42, 44-46 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* The Examiner states that *Tsai et al.* teaches a barrier layer being effective at a thickness of 10 angstroms and it would be obvious to use a thickness of 10 angstroms for the barrier layer as taught by an ALD process of *Lopatin et al.* '954. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 42 and claims dependent thereon.

Tsai et al., as stated by the Examiner, discloses only a barrier layer of 10-500 angstroms. Combination of *Tsai et al.* with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 42 and 44-69 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate depositing a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent to be deposited over a barrier layer having a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

H. Rejection of Claims 47-52 over *Lopatin et al.*'954 In vlew of *Lopatin et al.* '799, and in further view of *Tsai et al.*

Claims 47-52 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 47 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 47-52 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent to be deposited in a copper alloy seed layer comprising copper and the metal, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. In addition, *Tsai et al.*, does not disclose, suggest or motivate a second copper seed layer deposited over a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent. Accordingly, withdrawal of the rejection is respectfully requested.

I. Rejection of Claims 53-58 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*

Claims 53-58 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 53 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 53-58 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a first seed layer comprising aluminum. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, show, or suggest a second seed layer deposited over a first seed layer comprising aluminum. Further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, show, or suggest a first aluminum seed layer deposited to a sidewall coverage between a sub-monolayer and about 50 Å to be deposited over a

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thin barrier layer of a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

J. Rejection of Claims 59-69 over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*

Claims 59-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 59 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 59-69 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a seed layer comprising copper and aluminum to be deposited over a thin barrier layer deposited by ALD to a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

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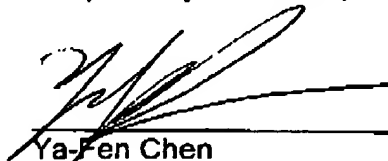
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The Examiner errs in finding that it would have been obvious to include a nitrogen graded copper alloyed seed layer as taught by *Lopatin et al.* '799 to be deposited over an ALD deposited barrier layer as disclosed by *Lopatin et al.* '954 to reject claims 1-7, 9-10, 39, 42, and 44-69 because *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, suggest, or motivate a seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof to be deposited over a barrier layer, the barrier layer having a thickness less than about 50 Å and deposited by atomic layer deposition.

The Examiner further errs in finding that it would have been obvious to include a barrier layer at a thickness of 10 angstroms as taught by *Tsai et al.* to be combined in an ALD deposited barrier layer as disclosed by *Lopatin et al.* '954 in view of a nitrogen graded copper alloyed seed layer as taught by *Lopatin et al.* '799 to reject claims 42 and 44-69 because *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, suggest, or motivate a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof to be deposited over a barrier layer, the barrier layer having a thickness less than about 20 Å and deposited by atomic layer deposition.

Respectfully submitted,



Ya-Fen Chen
Registration No. 51,553
Patterson & Sheridan, L.L.P.
3040 Post Oak Blvd. Suite 1500
Houston, TX 77056
Telephone: (713) 623-4844
Facsimile: (713) 623-4846
Agent for Appellant(s)

CLAIMS APPENDIX

1. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 50 Å;
depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof; and then
depositing a copper conductive material layer over the seed layer.
2. (Original) The method of claim 1, wherein the seed layer comprises a copper alloy seed layer of the copper and the metal.
3. (Original) The method of claim 1, wherein the seed layer comprises a first seed layer deposited over the barrier layer and a second seed layer deposited over the first seed layer.
4. (Original) The method of claim 3, wherein the first seed layer comprises a copper alloy seed layer of the copper and the metal.
5. (Original) The method of claim 4, wherein the second seed layer comprises undoped copper.
6. (Original) The method of claim 3, wherein the first seed layer comprises the metal.
7. (Original) The method of claim 6, wherein the second seed layer comprises undoped copper.
8. (Canceled)

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9. (Original) The method of claim 1, wherein the seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

10. (Original) The method of claim 1, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

11-38. (Cancelled)

39. (Previously Presented) A method of preparing a substrate structure for copper metallization, comprising:

depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less; and then

depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof.

40-41. (Cancelled)

42. (Previously Presented) A method of filling a feature, comprising:

depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å;

depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof; and then

depositing a copper conductive material layer over the copper alloy seed layer.

43. (Canceled)

44. (Original) The method of claim 42, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

45. (Original) The method of claim 42, wherein the copper alloy seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

46. (Original) The method of claim 42, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

47. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å;
depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof;
depositing a second seed layer over the copper alloy seed layer; and then
depositing a copper conductive material layer over the second seed layer.

48. (Original) The method of claim 47, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

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49. (Original) The method of claim 47, wherein the second seed layer comprises undoped copper.

50. (Original) The method of claim 47, wherein the copper alloy seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

51. (Original) The method of claim 47, wherein the second seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

52. (Original) The method of claim 47, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

53. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å;
depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å, the first seed layer comprising aluminum;
depositing a second seed layer over the first seed layer; and
depositing a conductive material layer over the second seed layer.

54. (Original) The method of claim 53, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

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55. (Original) The method of claim 53, wherein the second seed layer comprises undoped copper.

56. (Original) The method of claim 53, wherein the first seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

57. (Original) The method of claim 53, wherein the second seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

58. (Original) The method of claim 53, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

59. (Previously Presented) A method of preparing a substrate structure for electroplating of copper, comprising:

depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å; and

depositing a seed layer over the barrier layer, the seed layer comprising copper and aluminum.

60. (Original) The method of claim 59, wherein the seed layer comprises a copper alloy seed layer of the copper and the aluminum, the aluminum present in the copper alloy seed layer in a concentration between about 0.001 atomic percent and about 5.0 atomic percent.

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61. (Original) The method of claim 60, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.01 atomic percent and about 2.0 atomic percent.

62. (Original) The method of claim 60, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.1 atomic percent and about 1.0 atomic percent.

63. (Original) The method of claim 59, wherein the seed layer comprises a first seed layer deposited over the barrier layer and a second seed layer deposited over the first seed layer.

64. (Original) The method of claim 63, wherein the first seed layer comprises a copper alloy seed layer of the copper and the aluminum, the aluminum present in the copper alloy seed layer in a concentration between about 0.001 atomic percent and about 5.0 atomic percent and wherein the second seed layer comprises undoped copper.

65. (Original) The method of claim 64, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.01 atomic percent and about 2.0 atomic percent.

66. (Original) The method of claim 64, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.1 atomic percent and about 1.0 atomic percent.

67. (Original) The method of claim 63, wherein the first seed layer comprises aluminum to a sidewall coverage between a sub-monolayer and about 50 Å and wherein the second seed layer comprises undoped copper.

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68. (Original) The method of claim 59, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

69. (Original)The method of claim 59, wherein the seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

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EVIDENCE APPENDIX

No evidence is submitted.

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RELATED PROCEEDINGS APPENDIX

No copies of decisions rendered by a court or the Board in the related appeal or interference listed on page 4 of this Brief are included as there have been no related appeal or interference listed on page 4 of this Brief.